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Beazer

BEAZER EAST, INC., 436 SEVENTH AVENUE, PITTSBURGH, PA 15219

February 1, 1994

VIA UPS OVERNITE

Mr. Glenn Celerier, P.E.
EPA Project Coordinator (6H-SC)
Superfund Programs Branch
U.S. Environmental Protection Agency
Region VI
Allied Bank Tower at Fountain Place
1445 Ross Avenue
Dallas, TX 75202-2733

Re: South Cavalcade Superfund Site
Soil Remedy Evaluation Memorandum

Dear Glenn:

Enclosed is the Soil Remedy Evaluation Memorandum (SRE) faxed to your attention January 31, 1994 and as discussed in the conference call of January 19, 1994. The body of the document has remained unchanged from the version faxed yesterday. Please contact me at (412) 227-2004 if you have any questions.

Sincerely yours,

Steve Radel / jhB

Steven B. Radel
Associate Program Manager
Environmental Group

SBR/jjh

cc: Per Attached Distribution List

b:EPAres.fin\Beazer2

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DAMES & MOORE

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Final Draft

Soil Remedy Evaluation Memorandum
South Cavalcade Superfund Site
Houston, Texas

Beazer East, Inc.

D&M Job No. 18804-243-186

REV O **February 1994**

4601 CharlottePark Drive, Suite 320
Charlotte, North Carolina 28217

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Soil Remedy Evaluation Memorandum
South Cavalcade Superfund Site
Houston, Texas

Beazer East, Inc.

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1.0 Introduction

This Soil Remedy Evaluation Memorandum (SRE) discusses soil remedial actions for the South Cavalcade Superfund Site in Houston, Texas. The SRE has been prepared to demonstrate, in accordance with Section 8.1 of the September, 1988 Record of Decision (ROD), that in situ biological treatment of soil will provide equal or better performance than soil washing, and that implementability and short-term effectiveness questions can be resolved as discussed with the EPA on January 19, 1994. Moreover, as demonstrated during pilot tests, and as also discussed with the EPA, Beazer's soil washing and residual recycling plan will apparently fail to meet the EPA goals set forth in the ROD that all soils at the site be remediated to the risk based or leaching potential based remedial levels. The primary reference documents related to this memorandum are the Soil Washing Pilot Study Report (PSR, Dames & Moore, October 1993), EPA written comments of December 13, 1993 and January 12, 1994, and Beazer East, Inc. ("Beazer") responses of December 30, 1993.

1.1 Basis for Evaluation

Results of the PSR indicate a relatively large portion (more than 40 wt%) of the potentially impacted soils at the South Cavalcade site can not be treated to ROD goals using soil washing. The residual untreated fraction consists primarily of aggregate, aggregate sized pieces of pitch and tar-like materials, and a floatation froth wastestream. In light of this inability to treat all of the soils to ROD goals through soil washing and because of EPA's rejection of Beazer's residual waste recycling scenario, EPA has requested that Beazer perform an evaluation of residual management alternatives. As expressly permitted by Section 8.1 of the ROD and Section 9.3, Item 14 of the May, 1990 Statement of Work (SOW), Beazer has also evaluated in situ biological treatment of the soils as an alternative primary treatment. This memorandum details the evaluation and presents conclusions regarding the preferred remedial methods.

1.2 Primary Treatment Alternatives

The primary treatment alternatives that were evaluated for this SRE include:

- Soil washing

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- In situ biological treatment ("Bioremediation")
- Pre-screening and in situ bioremediation

Soil washing includes dry screening, wet screening, and froth floatation as the primary unit operations (see PSR). This process produces residual soil fractions, as well as a floatation froth stream, that do not meet ROD goals. However, advanced pilot testing indicates the process will remediate approximately 60% of the soils to the remediation levels set forth in the ROD.

In situ bioremediation describes a system installed at the surface, with minimal excavation, to deliver microbes, nutrients, and oxygen to the impacted soils. This process would be operated until the soils meet ROD goals. No specific residual streams are produced by this process.

Pre-screening and in situ bioremediation involves excavating the soils impacted at levels above ROD goals, and dry screening the soil to remove the oversized (plus +2-1/2") and aggregate (minus 2-1/2", plus 1/2") and aggregate sized pieces of pitch and tar-like materials. This pre-screened material becomes a residual stream, as in the case of soil washing, and requires disposal. The remaining soil would be amended with a bulking agent, such as coarse sand, and placed back into the excavation where in situ bioremediation can occur. A surface system would be installed to deliver microbes, nutrients and oxygen to promote the biodegradation of the constituents of concern (COCs).

1.3 Residual Stream Management Alternatives

Evaluation of the primary treatment alternatives is directly related to the selected residual stream management alternatives, which include:

- Off-site incineration
- Off-site land disposal

For this SRE, off-site incineration refers specifically to the Marine Shale Processors ("MSP") rotary kiln/quenching process in Morgan City, Louisiana which produces a granular structural fill material and is designated as MSP incineration in this bid evaluation. Off-site incineration is assumed to be available at MSP in Morgan City, Louisiana. Conventional incineration was not evaluated in this proposal for the following reasons:

- Conventional incineration produces contaminated waste water and hazardous ash by-products that require disposal. MSP uses a patented vitrification process to generate a non-hazardous aggregate product which exhibits no characteristics of a hazardous waste.
- As contemplated in the ROD, the cost of conventional incineration is 2-3 times the cost of MSP incineration. Therefore, conventional incineration, as well as costs associated with the disposal of the hazardous waste water and ash by-products generated during the process, is cost prohibitive. No additional hazardous waste by-products are generated in the MSP process, thus disposal costs are eliminated.

Similarly, off-site land disposal is assumed to be available at a permitted landfill such as the Texas Ecologists TSD in Robstown, Texas. Both of these facilities are have indicated they can receive CERCLA wastes such as the residuals that may be produced by the soil remediation at the South Cavalcade Site. Beazer would submit a request for approval to EPA prior to any shipments of waste leaving the site.

2.0 Technical Merit of Alternatives

2.1 Primary Treatment Alternatives

2.1.1 Soil Washing

General

Soil washing was previously selected by the EPA in the South Cavalcade Site ROD as the most appropriate remedial alternative for this site. However, EPA expressly stated in the ROD that it would consider in situ biological treatment "**if a potentially responsible party (PRP) can show that In Situ Biological Treatment of soil and groundwater will provide equal or better performance, and if the PRP can further ensure that the implementability questions can be resolved**" (ref. Section 8.1, ROD). Since the signing of the ROD, Beazer has had pilot scale testing performed to determine the effectiveness of soil washing at the South Cavalcade site. The detailed results of the pilot study are provided in the soil washing PSR. Key findings are reiterated here for clarity.

The soil washing pilot study provided valuable data regarding soil debris volumes and

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characteristics, and distribution and characteristics of the COCs in the soil matrix. Excavation of surficial soils in the southeastern area of the site uncovered debris including railroad ties, sticks, oyster shells, barstock, spikes and wire. Agglomerations of sticky coal tar pitch and coal tar coating were found in this debris. The large debris required manual removal during the feed operations to the SWACO soil washing equipment. Blinding and plugging problems were encountered throughout the dry and wet screening operations due to the large volume of debris and the adhesive nature of the coal tar residuals in the soil.

Performance

The pilot soil washing process was shown to be successful in reducing potentially carcinogenic polynuclear aromatic hydrocarbon (pcPAH) concentrations of selected soil fractions. However, soil particles larger than 10 mesh were not effectively treated due to the presence of particulate pitch and tarry materials in the coarse fractions of some of the test soils. Floatation testing, performed by Hazen Research, was found to be an effective washing method for the sand and silt fractions. Typical removal efficiencies on the six floatation tests varied from 51% to 100% for this fraction. Pilot study results are detailed in the soil washing PSR, December, 1993 and Beazer responses of December 30, 1993.

Residual Streams

Based on the results provided from the pilot test, a proposed full scale Process Flow Diagram (Figure 5, PSR, Dames & Moore, 1993) was developed. The basic process consists of dry screening and wet screening the feed soils above 10 mesh prior to froth floatation. The Product/Residual Stream Summary (ref. Table 1) lists the streams produced and shows that over 40 wt% of the feed soil becomes an untreated residual. The residual management options are also shown in Table 1.

The total feed soil tonnage of 9400 tons in Table 1 is based on the estimated soil quantities presented in the Soil Delineation Report (Keystone, August, 1992). This estimated quantity will be refined during the development of the bid documents as discussed in the December 15, 1993 meeting between the EPA and Beazer in Dallas. In this meeting, Beazer presented the geostatistically based soil delineation maps that will be used to establish preliminary "cut-lines" for the excavation of soils in the areas of concern.

Additionally, Beazer will employ geostatistical sampling as part of the confirmatory sampling program used during the soil remediation project. These approaches were discussed during the December 15, 1993 meeting with general agreement among EPA and Beazer representatives. The formalized approach and use of the geostatistical mapping and geostatistical sampling will be provided in the 30% Remedial Design submittal. 012288

The preliminary remedial plan proposed in the PSR involved the use of soil washing as the primary treatment method combined with recycle of the -2-1/2", +10 mesh aggregate and the froth slurry into a cold mix asphalt. The asphalt recycle option, if allowed, makes soil washing a more viable alternative. However, in the absence of asphalt recycling as an integral component, soil washing is not considered a success by EPA nor an economically viable solution to Beazer.

Technical Advantages and Disadvantages

The advantages offered by soil washing include:

- Soil washing meets the original methodology specified by the EPA.
- Soil washing effectively washes approximately 60% of the soils at the site to ROD goals.

The disadvantages offered by soil washing include:

- Soil washing can not meet ROD goals for approximately 40% of the soils at the site.
- The potential for more clays to be present at the site than indicated during the pilot tests will increase the quantity of soil that cannot be washed to ROD goals.
- Wet processing of the impacted soils presents a slightly higher but manageable risk to system operators than imposed by in situ remedial methods.
- Due to the generation of approximately 40 wt% of residual materials, this process requires alternative treatment or disposal methods.

2.1.2 In Situ Bioremediation

General

In situ soil bioremediation describes the process by which the organic compounds in soils in-place are biologically degraded under controlled, enhanced conditions. Bioremediation of the COCs at South Cavalcade will yield carbon dioxide and water as by-products.

Performance

Bioremediation of PAHs and pcPAHs is a remedial alternative not only recognized in the ROD for the South Cavalcade site but in the ROD's for 17 other CERCLA sites as listed in Table 9. Biodegradation of pcPAHs has been demonstrated to reduce pcPAH concentrations in soil to less than the 700 ppm (the South Cavalcade ROD goal) in bench, pilot, and full scale applications as presented in Table 8. Further, EPA's Gulf Breeze Laboratories in Florida has developed a microbial population that specifically degrades the higher molecular weight pcPAHs while existing simultaneously in the presence of indigenous bacteria.

There are also dozens of bench scale treatability tests sponsored by EPA that demonstrate the success of biodegradation of PAHs. In recent years, EPA's Superfund Technology Demonstration Division has sponsored several seminars promoting biodegradation as a viable treatment methodology for PAHs. Further, the half lives of the COCs in these tests are generally less than 6 months, which indicates that data regarding the short term effectiveness of bioremediation has notably improved since EPA developed the ROD for the South Cavalcade site.

In situ bioremediation is particularly well suited in areas where soils remain moist, where delivery of nutrients to the soil can be managed from the surface, and where the time required for remediation is not prohibitively short due to constraints on land usage.

Technical Advantages and Disadvantages

In situ bioremediation has several advantages including:

- Existing data for other sites indicates the ability to biodegrade COCs such as those present at South Cavalcade.

- Construction of the system is not complex.
- Risk of exposure to field teams is reduced because no significant material handling is performed.
- Residual wastestreams are not produced.

The potential disadvantages of in situ bioremediation include:

- Site specific biotreatability testing should be performed to determine design criteria and to more accurately project remediation time.

The impacted site soils have been shown to contain debris that may lengthen the time to biodegrade the COCs in the soil matrix. Therefore, site specific biotreatability testing would have to be performed prior to selection of in situ bioremediation as a remedy to ensure that implementability questions can be resolved.

2.1.3 Pre-screening and In Situ Bioremediation

This alternative combines in situ bioremediation with soil pre-screening to expedite the biological degradation of COCs not adhered to screened fractions. Excavation, debris removal, bulking and mixing operations are performed on the excavated soils prior to replacing them in the excavation for subsequent bioremediation.

Pre-screening involves the removal of oversize debris and coated aggregate-sized soil fractions larger than ½" particle size. In certain areas of the site, these fractions also may contain quantities of viscous tar agglomerations, coated aggregates, and aggregate-sized tar-like pieces. After removing these fractions, the remaining soil can be bulked and amended. The mixed soils will be returned to the excavated areas where a surface distribution system will deliver oxygen, nutrients and microbes to the soil (if dictated by treatability test results).

The residual streams that would be created are similar to those created through soil washing and are shown in Table 2. However, the percentage of residual material generated would be significantly reduced and the floatation froth residual stream is eliminated.

Pre-screened in situ bioremediation has several advantages. Among them are:

- Existing data for other sites indicates the ability to degrade COCs such as those present at South Cavalcade.

- Construction of the system is not complex.

- Biological degradation of soils that contain agglomerating of COC's is expedited.

The disadvantages of pre-screened in situ bioremediation include:

- Site specific biotreatability testing should be performed to determine design criteria and to more accurately project remediation time.

- Excavation of impacted soils which will increase potential exposure to on-site workers.

- The alternative produces residual +1/2" aggregate and debris streams estimated at 20 wt% of the feed soil in selected areas of the site. These residual materials must be managed.

2.2 Residual Streams Management Alternatives

The selection of a soil remedial alternative which minimizes the volume of the residuals streams generated should be a primary goal. The costs associated with treatment, handling and disposal of residuals streams can be significant. MSP incineration and landfill disposal as residuals management alternatives were evaluated in this SRE.

2.2.1 Off-site Incineration

MSP incineration is a technically viable residual streams management alternative. Both solid and slurry phase residual streams produced from either soil washing or in situ bioremediation with pre-screening are acceptable for MSP incineration. However, some of the residual streams may require a significant amount of materials preparation. The large wood debris would require shredding; the froth produced by soil washing would require dewatering (filter press, rotary vacuum filter, etc.). The filtered water would then require additional filtration and biological treatment prior to discharge.

MSP in Morgan City, Louisiana, operates a recycling facility which manufactures a non-hazardous aggregate from waste products. The waste products are fed into a rotary kiln for volatilization and/or combustion of the COCs. The aggregate produced by pre-screened bioremediation would be processed similarly. The remaining solid product would then be quenched, melted, and shattered in a cooling water tank, forming a granular end-product. Currently, the end-product is beneficially being used as structural fill at a construction site in Louisiana. The product produced by MSP has been proven to be environmentally safe. A processing rate of up to 22 tons per hour, and efficient operation, allow MSP to price disposal services at less than one-half the cost of conventional incinerator processing.

As described above, MSP has indicated that CERCLA materials can be processed through this facility. Beazer would comply with the notification provisions of the Consent Order and will obtain EPA approval prior to initiating this alternative.

2.2.2 Off-site Landfill

Disposal at a permitted off-site landfill is a technically viable option for residual stream management. The solid and slurry phase residual streams produced from either soil washing or in situ bioremediation are acceptable for landfilling. Testing of these residual streams will be performed by the landfill operator to determine what waste preparation steps must be taken, if any, prior to disposal. Texas Ecologists operates a federally permitted landfill in Robstown, Texas which ensures that the landfill is designed and operated in accordance with federal guidelines and regulations. Beazer would comply with the notification provisions of the Consent Order and will obtain EPA approval prior to initiating this alternative.

3.0 Cost Comparison of Alternatives

3.1 Cost Basis/Cost Data

Costs for implementing in situ bioremediation with and without pre-screening, and soil washing remedial alternatives were estimated with residuals disposal via landfill and MSP incineration. The costs shown in the Tables 3 through 7 reflect data from various sources. The soil washing costs reflect both quoted and actual costs of pilot tests performed for Beazer. The MSP incineration costs are based on pricing from MSP. As discussed in section 1.3 above, and as contemplated in the ROD, conventional incineration is not included as a feasible alternative due to the high cost associated with this alternative. The

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cost of conventional incineration would more than double the MSP quoted price and are not included in this evaluation. Landfill disposal costs are based on pricing supplied for the Texas Ecologists facility in Robstown, Texas.

The cost basis for each cost item is specified in the tables. The overall basis for the cost tables is 9400 tons of soils to be excavated at the site with the fractions distributed as shown in Table 1. As noted earlier, the 9400 tons is based on the Soil Delineation Report (Keystone, August, 1992) and will be refined using geostatistical mapping and geostatistical analysis of field data generated during excavation. Sampling and analytical costs are not included in the cost estimates. The soil washing unit is assumed to operate at 8 tons per hour. Both in situ bioremediation scenarios are conservatively estimated to require a 36 month duration using forced aeration and/or surface tilling, and surface irrigation/nutrient delivery. These details of the bioremediation design will be determined after completion of biotreatability tests.

Cost Summary

From the tables it can be seen that in situ bioremediation offers the least costly alternative and in situ bioremediation with pre-screening and landfill disposal of the pre-screened residual debris offers the next most economical remedial alternative.

Soil washing, with residual stream management in a landfill or incinerator, is the most costly primary remedial option. Construction, operation and chemical costs far exceed the bioremediation alternative. Two additional residual streams not present in the bioremediation option are generated by soils washing and require treatment and disposal. Furthermore, the risk of employing this remedial option is relatively high given the absence of data from a full scale system which has successfully remediated the organic constituents and soil conditions present at the South Cavalcade site.

4.0 Conclusions

The soil washing remedial action alternative selected by the EPA in the ROD is not technically viable for all soils as originally envisioned due to the following factors that have been developed through Beazer's soil delineation sample analysis evaluation and soil washing pilot test activities. These factors indicate that soil washing has also become a less cost-efficient remedial alternative.

- The total volume of soil to be cleaned is now only estimated to be 9400 tons (6962 cubic yards) instead of the 30,000 cubic yards originally estimated. As discussed earlier, the estimated 9400 tons is based on the Soil Delineation Report (Keystone, August, 1992) and will be refined using geostatistical mapping and analysis during the bid package development. Therefore, economies of scale will not be attained due to the decrease in the volume requiring remediation.

- Only about 60 wt% of the impacted soils can be washed and cleaned to ROD remedial levels due to soil and COCs characteristics.

- EPA has rejected Beazer's proposed use of the froth solids and -2-1/2", +10 mesh soil fractions in a cold mix asphalt. These components comprise approximately 40 wt% of the feed soils. The cost to MSP incinerate or landfill these fractions disproportionately increases the cost of soil washing.

- Significant effort and expense not originally anticipated will be required to handle, stage, transport and dispose of the residual streams, including aggregate and floatation froth slurry.

4.1 Preferred Alternatives

As expressly permitted by Section 8.1 of the ROD, EPA should consider in situ biological treatment of soil as an alternate remediation plan, because as demonstrated herein, bioremediation will provide equal or better performance than soil washing, short-term effectiveness and implementability questions previously contemplated in the ROD can be resolved, and bioremediation is far more cost-efficient than soil washing. The pre-screened bioremediation alternative offers the lowest residual stream volumes and cleans, in place, more than 70% of the impacted soils to ROD remediation levels, whereas soil washing results in a higher volume of residual streams, and cleans only 58% of the impacted soils to ROD levels. Moreover, in situ bioremediation costs far less than soil washing. Technological improvements in bioremediation methods and design have enhanced biological degradation of pcPAHs and shortened cleanup times (estimated conservatively as 18 to 36 months).

It is probable, based on recent and numerous bench, pilot and field scale tests, that a properly designed bioremediation system and applied remedial technology will be successful in meeting the ROD goal of 700 ppm pcPAHs for the soils to be remediated. Preliminary data from biotreatability testing may determine the effectiveness of bioremediation in as little as 6-9 weeks after the implementation of testing. 012295

In situ bioremediation or in situ bioremediation with pre-screening and disposal of the residual streams in an approved landfill are the most cost-efficient, technically feasible remedial alternatives. In situ bioremediation with pre-screening and residual stream disposal via incineration at MSP's facility is the third most cost-efficient alternative.

Beazer would be able to draw on the experience of specialty consultants with experience in bioremediation of sites with similar COCs in effecting an in situ bioremediation soil remedy. Moreover, existing design criteria from American Creosote Works, Southern Wood Piedmont, Kerr McGee and Beazer projects would be evaluated for use in the South Cavalcade project.

4.2 Final Evaluation Criteria

An assessment of various soil remedial alternatives was performed by the EPA and documented in the ROD. The preferred remedy identified by this evaluation was also evaluated based on nine criteria as prescribed in OSWER Directive 9355.0-21 and summarized below. The following assesses in situ bioremediation vis-a-vis soil washing pursuant to those nine criteria:

- Compliance with Environmental Laws - Bioremediation and disposal of the residuals can be managed to meet all existing federal and state environmental laws as demonstrated by the entered "0" rating in the ROD.

- Reduce Toxicity, Mobility and Volume - Bioremediation will provide effective reductions in the toxicity, mobility and volume of the impacted soils to a greater extent than soil washing.

- Short-Term Effectiveness - It is conservatively estimated that each bioremediation system, properly designed and constructed to maximize biodegradation conditions, will reach the ROD remediation parameters for soils to be remediated in 18 to 36 months. Improved technology since the signing of the ROD helps this alternative meet the short-term effectiveness criterion nearly as well as soil washing does. Further, the groundwater collection system will be in place at this time and will capture any potentially migrating COCs during the in situ bioremediation timeframe. The remediation area can be temporarily fenced thus preventing exposure to the surface soils. These combined features meet or exceed the potential risk requirement of no exposure pathways (i.e. neither ingestion or contact with soils nor ingestion due to potential impacts to groundwater). These features clearly improve the short term effectiveness of the selected remedial method.

- Long-Term Effectiveness - Bioremediation will biologically and permanently degrade the targeted COCs in volumes greater than soil washing will.

- Implementability - Based on documented successful experience at other sites and improved technology since the signing of the ROD, bioremediation is no more difficult to implement, and likely easier to implement, than soil washing. The ROD noted bioremediation as "-" for implementability in the southeastern area because of the potential for migration of COCs carried by irrigation water off-site below the railroad tracks adjacent to the site. The bioremediation alternative recommended in this evaluation requires only marginal irrigation, as opposed to soil flushing, that was considered in the FS. Further, the groundwater gradient flows away from the railroad tracks thus impeding flow toward the railroad tracks. Finally, the groundwater collection system will be in place and will further impede any migration of impacted groundwater from the site. These features clearly address the implementability concern expressed in the ROD.

- Cost - Bioremediation is a far more cost-efficient remedial alternative than soil washing.

- Community Acceptance - Bioremediation poses no community acceptance problems greater than soil washing does and was rated as "0" by the EPA in the ROD.

- Protection of Human Health & the Environment - Bioremediation permanently reduces the toxicity of impacted soils and provides minimal exposure to either humans or the environment. The bioremediation plots are closely monitored and designed to minimize any leachate migration or stormwater runoff. In the ROD, EPA rated bioremediation as "0" with respect to this criterion, just as in soil washing.

4.3 Recommendations

In situ bioremediation or pre-screening and in situ bioremediation combined with landfill of the pre-screened residuals are the most effective and cost efficient soil remediation alternatives which should be employed at the South Cavalcade site. Biotreatability testing should begin immediately, pending EPA approval, in order to

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generate biodegradation design data. Results of treatability testing will determine the preferred oxygen delivery method, nutrient requirements, and projected degradation period for both the in situ bioremediation and in situ bioremediation with pre-screening options. Selection of the final biotreatment system(s) and specific design details of the bioremediation system can begin at that time. Design of the civil work and pre-screening operations, if required, can begin upon EPA approval to proceed.

4.4 Schedule Impact

Beazer will make every effort to adhere to the current South Cavalcade Summary Project Schedule (EPA Monthly Progress Report, December 31, 1993). It is anticipated that the 100% remedial design submittal will be accomplished on September 25, 1994 for EPA approval per the current schedule.

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TABLE 1

PRODUCT/RESIDUAL STREAMS SUMMARY - SOIL WASHING

Product/Residual Streams	Est. pcPAH Conc. (ppm)	Estimated Tonnage	Stream Type	Residual Management Options
Feed	1700	9,400	Feed	NA
+6" debris	NA	470	Residual	Landfill
-6",+2-1/2" debris	NA	190	Residual	Landfill
-2-1/2",+1/2" aggregate	1500	1,220	Residual	Landfill or MSP Incineration
-1/2",+10 mesh aggregate	1700	850	Residual	Landfill or MSP Incineration
Floatation Tailings	600	5,450	Washed	Return to Excavation
Floatation Froth	5000	1,220 Dry Basis 2,440 Wet Basis (50 wt% solids)	Residual	Landfill, Treatment or MSP Incineration
Wash Water	NA	NA	Residual	Pre-Treatment & Disposal via Onsite GWTP

TABLE 2

PRODUCT/RESIDUAL STREAMS SUMMARY - BIOREMEDIATION WITH PRE SCREENING

Product/Residual Streams	Est. pcPAH Conc. (ppm)	Estimated Tonnage	Stream Type	Stream Disposition Options
Feed	1700	9,400	Feed	NA
+6" debris	NA	470	Residual	Landfill
-6",+2-1/2" debris	NA	190	Residual	Landfill
-2-1/2",+1/2" aggregate	1500	1,220	Residual	Landfill or MSP Incineration
-1/2" soil	1880	7,520	Biotreated to ROD goal	In Situ Bioremediation

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TABLE 3

IN SITU BIOREMEDIATION

Cost Item	Cost Basis	Cost ($)
Treatability Testing	Estimate	$100,000
Remedial Design	Estimate	$50,000
RA Planning	Estimate	$35,000
Site Preparation	Equipment pads	$30,000
Mobilization	Estimate	$5,000
Excavation and Screening	NA	NA
Equipment Cost	$10,000 for nutrient package and $10,000 for piping - 3 areas	$60,000
O&M Labor	$20,000/Yr 3 Yr Duration	$60,000
O&M Materials	$500/Month 3 Yr Duration	$18,000
Nutrients	$10/Ton 3 Yr Duration 9,400 Tons/Yr	$282,000
Residuals Management		
Transportation	NA	NA
+2½" Solids	NA	NA
-2½", +½"	NA	NA
Backfill	NA	NA
Demobilization	NA	NA
Site Closure	18" gravel cap over 55,000 sq. ft. $16/Cu Yd installed	$50,000
RA Oversight	4 Week Duration 60 Hrs/Wk at $75/Hr	$18,000
Closure Report	Estimate	$30,000
	Total	**$738,000**

TABLE 4

PRE-SCREENING/IN SITU BIOREMEDIATION WITH LANDFILLING

Cost Item	Cost Basis	Cost ($)
Treatability Testing	Estimate	$100,000
Remedial Design	Estimate	$100,000
RA Planning	Estimate	$50,000
Site Preparation	Haul roads Soil staging areas Equipment pads Clear and grade	$100,000
Mobilization	Contractor bids on similar jobs	$50,000
Excavation and Screening	$15/Ton for excavation $35/Ton for screening 9,400 tons excavated 1,880 tons screened out	$470,000
Equipment Cost	$20,000 each for equipment and $20,000 for piping - 3 areas	$120,000
O&M Labor	$25,000/Yr 3 Yr Duration	$75,000
O&M Materials	$1,000/Month 3 Yr Duration	$36,000
Nutrients	$10/Ton 3 Yr Duration 9,400 Tons/Yr	$282,000
Soil Amendment	$10/Ton 1,880 tons of coarse sand	$18,800
Residuals Management		
Transportation +1/2" aggregate/debris	$50/Ton 1,880 Tons	$94,000
+2½" Solids	$150/Ton 660 Tons	$99,000
-2½", +½"	$200/Ton 1220 Tons	$244,000
Backfill to Excavation	$10/Ton 9,400 Tons	$94,000
Demobilization	Estimate	$50,000

TABLE 4

PRE-SCREENING/IN SITU BIOREMEDIATION WITH LANDFILLING (Cont.)

Cost Item	Cost Basis	Cost ($)
Site Closure	18" gravel cap over 55,000 sq. ft. $16/Cu Yd installed	$50,000
RA Oversight	10 Week Duration 60 Hrs/Wk at $75/Hr	$45,000
Closure Report	Estimate	$30,000
	Total	**$2,107,800**

TABLE 5

PRE-SCREENING/IN SITU BIOREMEDIATION WITH MSP INCINERATION

Cost Item	Cost Basis	Cost
Treatability Testing	Estimate	$100,000
Remedial Design	Estimate	$100,000
RA Planning	Estimate	$50,000
Site Preparation	Haul roads Soil staging areas Equipment pads Clear and grade	$100,000
Mobilization	Contractor bids on similar jobs	$50,000
Excavation and Screening	$15/Ton for excavation $35/Ton for screening 9,400 tons excavated 1,880 tons screened out	$470,000
Equipment Cost	$20,000 each for equipment and $20,000 for piping - 3 areas	$120,000
O&M Labor	$25,000/Yr 3 Yr Duration Process Operations	$75,000
O&M Materials	$1,000/Month 3 Yr Duration	$36,000
Nutrients	$10/Ton 3 Yr Duration 9,400 Tons/Yr	$282,000
Soil Amendment	$10/Ton 1,880 tons of coarse sand	$18,800
Residuals Management		
Transportation +1/2" Debris	$50/Ton 1,880 Tons	$94,000
+2½" Solids	$500/Ton 660 Tons	$330,000
-2½", +½"	$500/Ton 1220 Tons	$610,000
Backfill to Excavation	$10/Ton 9,400 Tons	$94,000
Demobilization	Estimate	$50,000

TABLE 5

PRE-SCREENING/IN SITU BIOREMEDIATION WITH MSP INCINERATION (Cont.)

Cost Item	Cost Basis	Cost
Site Closure	18" gravel cap over 55,000 sq. ft. $16/Cu Yd installed	$50,000
RA Oversight	10 Week Duration 60 Hrs/Wk at $75/Hr	$45,000
Closure Report	Estimate	$30,000
	Total	**$2,704,800**

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TABLE 6

SOIL WASHING WITH LANDFILLING

Cost Item	Cost Basis	Cost
Treatability Testing	Actual Pilot Tests (Costs incurred in 1993)	$300,000
Remedial Design	Estimate	$200,000
RA Planning	Estimate	$100,000
Site Preparation	Haul roads Soil staging areas Extended process pad Clear and grade	$150,000
Mobilization	Contractor bids on similar jobs	$200,000
Excavation and Screening	$15/ton for excavation $35/ton for screening 9,400 tons excavated 2,730 tons screened out	$470,000
Equipment Cost	Contractor bids on similar jobs $5,000/day 8 tons/hr 8 hrs/day 30% down time (1) 6,670 tons treated (-10 mesh soil fraction - dry basis) 150 days total	$750,000
O&M Labor	Contractor bids on similar jobs $4,500/day 150 days Pile management Health and Safety Process operators	$675,000
O&M Materials	South Cavalcade pilot test actuals 6,670 tons 1% surfactant at $1.50/lb. $20/ton for other additives Replacement screens $30,000	$363,500
Soil Amendment	(1) 3,950 tons (includes all residual streams, dry basis - ref. Table 1) $10/ton	$39,500
Residuals Management		
Transportation	(1) $50/ton for 5,170 tons (includes all residual streams, wet basis - ref. Table 1)	$258,500

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TABLE 6

SOIL WASHING WITH LANDFILLING (Cont.)

Cost Item	Cost Basis	Cost
+2½" Solids	(1) $150/ton for 660 tons	$99,000
-2½", +½"	(1) $200/ton for 1220 tons	$244,000
-½", +10 mesh	(1) $200/ton for 850 tons	$170,000
Froth Slurry	(1) $275/ton for 2,440 tons	$671,000
Wash Water	5 gpm blowdown 8 hrs/day 150 days 50¢/gallon for treatment	$180,000
Backfill to Excavation	9,400 tons $10/ton	$94,000
Demobilization	Contractor bids on similar jobs	$150,000
Site Closure	18" gravel cap over 55,000 sq. ft. $16/cubic yard installed	$50,000
RA Oversight	16 week duration 60 hrs/wk at $75/hr	$72,000
Closure Report	Estimate	$30,000
	Total	**$4,966,500**(2)

Note 1: Reference Table 1 for Tonnages

Note 2: This total does not include the $300,000 pilot treatability testing. This money has already been expended and is not appropriate for a future cost comparison.

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TABLE 7

SOIL WASHING WITH MSP INCINERATION

Cost Item	Cost Basis	Cost
Treatability Testing	Actual Pilot Tests (Costs incurred in 1993)	$300,000
Remedial Design	Estimate	$200,000
RA Planning	Estimate	$100,000
Site Preparation	Haul roads Soil staging areas Extended process pad Clear and grade	$150,000
Mobilization	Contractor bids on similar jobs	$200,000
Excavation and Screening	$15/Ton for excavation $35/Ton for screening 9,400 tons excavated 2,730 tons screened out	$470,000
Equipment Cost	Contractor bids on similar jobs $5,000/Day 8 Tons/Hr 8 Hrs/Day 30% Down Time (1) 6,670 tons treated (-10 mesh soil fraction - dry basis) 150 days total	$750,000
O&M Labor	Contractor bids on similar jobs $4,500/Day 150 Days Pile Management Health and Safety Process Operators	$675,000
O&M Materials	South Cavalcade pilot test actuals 6,670 tons soil 1% surfactant at $1.50/lb. $20/ton for other additives Replacement screens $30,000	$363,500
Soil Amendment	(1) 3,950 Tons (includes all residual streams, dry basis - ref. Table 1) $10/Ton	$39,500
Residuals Management		

TABLE 7

SOIL WASHING WITH MSP INCINERATION (Cont.)

Cost Item	Cost Basis	Cost
Transportation	(1) $50/Ton for 5,170 Tons (includes all residual streams, wet basis - ref. Table 1)	$258,500
+2½" Solids	(1) $500/Ton for 660 Tons	$330,000
-2½", +½"	(1) $500/ton for 1220 Tons	$610,000
-½", +10 mesh	(1) $500/Ton for 850 Tons	$425,000
Froth Slurry	(1) $600/Ton for 2,440 Tons	$1,464,000
Wash Water	5 gpm blowdown 8 Hrs/Day 150 Days 50¢/gallon for treatment	$180,000
Backfill to Excavation	9,400 Tons $10/Ton	$94,000
Demobilization	Contractor bids on similar jobs	$150,000
Site Closure	18" gravel cap over 55,000 sq. ft. $16/cubic yard installed	$50,000
RA Oversight	16 Week Duration 60 Hrs/Wk at $75/Hr	$72,000
Closure Report	Estimate	$30,000
	Total	**$6,611,500**(2)

Note 1: Reference Table 1 for Tonnages
Note 2: This total does not include the $300,000 pilot treatability testing. This money has already been expended and is not appropriate for a future cost comparison.

TABLE 8

SUMMARY OF BIODEGRADATION PROJECTS ON PAH-CONTAMINATED SOIL

LOCATION	SPONSOR	CONTAMINANT OF CONCERN	INITIAL CONC. (mg/kg)	FINAL CONC. (mg/kg)	HALF LIFE (days)	TEST SCALE	MATRIX	SOURCE
Burlington Northern Minneapolis, MN	Burlington Northern	CPAH	1600	550	115	Full	Soil	Lynch (1989)
International Paper Wiggins, MS	EPA-Kerr ERL	TPAH	3954	ND	2-117	Full	Soil	Pope (1990)
J.H. Baxter Weed, CA	Superfund	TPAH	3398-13,655	ND-4194	--	Pilot	Soil	McGinnis (1990)
Am. Creosote Works Pensacola, FL	EPA-Gulf Breeze	CPAH	525	286	92	Bench	Soil	Mueller (1991a)

References

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Mueller, J.G., Lantz, S.E., Blatmann, B.O., Chapman, P.J. (1991b) "Bench-Scale Evaluation of Alternative Biological Treatment Processes for the Remediation of Pentachlorophenol- and Creosote-Contaminated Materials: Slurry-Phase Bioremediation", Environmental Science and Technology ESTHAG, 25, p. 1055-1061.

Pope, D.F., Templeton, M.C., McGinnis, G.D., Borazjani, A., Strobel, D. (1990) "Land Treatment at the U.S. EPA Demonstration Unit in Wiggins, Mississippi", Proceedings on the Remediation of Wood Treating Waste in Groundwater, Soil, and Process Streams, p. 159-184.

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TABLE 9

SUMMARY OF SUPERFUND RODs EMPLOYING BIOREMEDIATION

SITE	CONTAMINANT OF CONCERN	TREATMENT TYPE
L.A. Clarke & Son, Inc. Fredericksburg, VA	CPAH PAH	Solid Phase, In-situ & Solid Phase, Ex-situ
Brown Wood Preserving Live Oak, FL	PAH	Solid Phase, Ex-situ
Libby Groundwater Contamination Site, Libby, MT	CPAH PAH	Solid Phase, In-situ & Solid Phase, Ex-situ
Cliff/Dow Dump, Marquette, MI	CPAH, PAH	Solid Phase, Ex-situ
Koppers Co., Inc., Oroville, CA	PAH	Solid Phase, In-situ
American Creosote Works, Inc. Pensacola, FL	PAH	Solid Phase, Ex-situ
Woodland TWP, Route 72 Woodland TWP, NJ	PAH	Aqueous Phase, Ex-situ
Coakley Landfill, Greenland, NH	PAH	Aqueous Phase, Ex-situ
Moss-American Kerr-McGee Oil Co. Milwaukee, WI	PAH	Slurry Phase, Ex-situ
Coleman-Evans Wood Preserving Jacksonville, FL	PAH PCP	Aqueous Phase, Ex-situ
Dubose Oil Products Co. Cantonment, FL	PAH	Solid Phase, Ex-situ
Cabot/Koppers Gainesville, FL	CPAH, Phenol Ar, Cl	Aqueous Phase, Ex-situ & Solid Phase, In-situ
J.H. Baxter, Weed, CA	CPAH, Dioxin	Solid Phase, Ex-situ
Peoples Natural Gas Co. Dubuque, IA	CPAH PAH	Solid Phase, In-situ Aqueous Phase, In-situ
MacGillis & Gibbs Co./Bell Lumber & Pole, New Brighton, MN	PCP	Aqueous Phase, Ex-situ
Charles Macon Lagoon & Drum Storage, Cordova, NC	PAH PCE	Solid Phase, Ex-situ
Idaho Pole Co. Bozeman, MT	CPAH PAH, PCP	Solid Phase, Ex-situ Aqueous Phase, Ex-situ Aqueous Phase, In-situ